

REMARKS

Claims 29, 34, 45, 46, 58, and 59 have been amended. No claims have been added or canceled. Accordingly, Claims 23 - 60 remain pending.

Claims 29, 31, 34, 35, 45, 46, and 58 - 60 have been objected to on various grounds.

More particularly, the phrase "into the opening above material of the cobalt layer at the bottom of the opening" in each of Claims 45 and 58 has been objected to as being ambiguous.

The objected-to phrase in Claims 45 and 58 has been changed to "into the opening so as to overlie cobalt of the cobalt layer at the bottom of the opening". Consequently, Claims 45 and 58 each now recite that "the titanium layer is formed to extend at least into the opening so as to overlie cobalt of the cobalt layer at the bottom of the opening". This language seems clear and non-ambiguous to Applicant's Attorney. Hence, the objection to Claims 45 and 58 should be withdrawn.

The terminology "largely of silicon" in Claims 59 and 60 has been objected to as being relative terminology that makes the two claims indefinite.

The federal courts have long accepted the use of relative terms such as "approximately", "substantially", "essentially", and "largely", and the like in U.S. patent claims. Accordingly, the objection to the use of relative terminology in Claims 59 and 60 as making those claims indefinite is an inappropriate objection and should be withdrawn.

With respect to Claims 46 and 59, the Examiner has suggested that the phrase "removing material of the silicon oxide" be changed to "removing a portion of the silicon oxide".

Claims 46 and 59 have been revised in a manner similar to what the Examiner has suggested. To avoid the possibility that "a portion" could be construed to mean only one section of the silicon oxide (layer), the word "material" at the indicated places in Claims 46 and 59 has been changed to "part" (not "a part") since "part" encompasses one or more portions. Claims 46 and 59 now recite "removing part of the silicon oxide". This phraseology is clear to Applicant's Attorney. The objection to Claims 46 and 59 should therefore be removed.

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Claims 29 and 34 have been modified in the manner suggested by the Examiner. That is, "comprised by" in each of those claims has been changed to "comprised of".

The Examiner alleges that the phrase "the other of the source/drain regions" in Claims 31 and 35 is unclear (to the Examiner). In each of Claims 31 and 35, the Examiner has referred parenthetically to line 2 where the indicated phrase appears and also parenthetically to line 5 which recites "that other of the source/drain regions" rather than "the other of the source/drain regions".

Claims 31 and 35 are dependent claims and, as such, must be read in light of the claims from which they depend. When so read, the phrase "the other of the source/drain regions" at line 2 in each of Claims 31 and 35 is clear.

In particular, Claim 31 depends from Claim 28 which specifies that the substrate contains a pair of source/drain regions and that a cobalt silicide layer is formed to contact "one" of the source/drain regions. Claim 31 specifies that a further cobalt silicide layer is formed over "the other" of the source/drain regions. Since Claim 28 specifies that a cobalt silicide layer is formed to contact "one" of the source/drain regions, "the other" source/drain region covered by the further cobalt silicide layer of Claim 31 is the source/drain region other than the source/drain region contacted by the cobalt silicide layer of Claim 28.

For example, if the two source/drain regions of Claim 28 are described as the first and second source/drain regions, Claim 28 permits its cobalt silicide layer to contact either source/drain region, i.e., the first source/drain region or the second source/drain region. If the cobalt silicide layer of Claim 28 contacts the first source/drain region, "the other" source/drain region of Claim 31 is the second source/drain region. Conversely, "the other" source/drain region of Claim 31 is the first source/drain region if the cobalt silicide layer of Claim 28 contacts the second source/drain region. In each case, "the other" source/drain region of Claim 31 is the source/drain region not contacted by the cobalt silicide layer of Claim 28. Consequently, the meaning of "the other" source/drain region at line 2 of Claim 31 is clear.

Similarly, Claim 35 depends from Claim 33 which specifies that the substrate contains a pair of source/drain regions and that a cobalt silicide layer is formed to contact "one" of the source/drain regions. As with Claim 31, Claim 35 specifies that a further cobalt silicide layer is formed over "the other" of the source/drain regions. Because Claim 33

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specifies that a cobalt silicide layer is formed over "one" of the source/drain regions, "the other" source/drain region of Claim 35 is the source/drain region not contacted by the cobalt silicide layer of Claim 33. The meaning of "the other" source/drain region of Claim 35 is thus clear.

At line 5 of Claim 31, "that other of the source/drain regions" is "the other" source/drain region recited at line 2 of Claim 31. Similarly, "that other of the source/drain regions" at line 5 of Claim 35 is "the other of the source/drain regions" recited at line 2 of Claim 35. The language "that other of the source/drain regions" in Claims 31 and 35 is therefore also clear. The objections to Claims 31 and 35 should be withdrawn.

Claims 23 - 26, 50, 51, and 53 have been rejected under 35 USC 103(a) as obvious based on "applicant's admitted prior art", presumably the material disclosed in the Background section of the present application at pages 1 and 2, taken with Choi, U.S. Patent 6,337,245 B1. This rejection is respectfully traversed.

The Background material disclosed on pages 1 and 2 of the specification is, for convenience, hereafter generally referred to using the Examiner's terminology "applicant's admitted prior art" ("AAPA"). Largely repeating what was stated in the Amendment submitted 21 June 2004, the starting point for AAPA is a fixed-threshold insulated-gate field-effect transistor having doped polycrystalline silicon ("polysilicon") gate electrode 100 and a pair of doped monocrystalline silicon ("monosilicon") source/drain regions 101. Cobalt layer 120 is sputter deposited on top of the structure. Titanium layer 130 is sputter deposited on cobalt layer 120. An anneal is performed to create cobalt silicide layer 210 from cobalt in cobalt layer 120 and silicon in gate electrode 100 and source/drain regions 101. Titanium layer 130 and any unreacted cobalt are subsequently removed.

Choi discloses a technique for manufacturing an erasable programmable read-only memory ("EPROM") of the flash-erasable type. Each memory cell of Choi's EPROM contains a pair of source/drain regions, an electrically insulated floating gate situated over a channel region extending between the source/drain regions, and a control gate (electrode) situated over the floating gate. To make the upper surface of the EPROM relatively flat, Choi deposits a relatively thick layer of electrically insulating material and then performs chemical-mechanical polishing.

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The floating gate in each memory cell of Choi's EPROM consists of conductively doped polysilicon. At col. 9, line 51, through col. 10, line 6, Choi discloses that self-aligned silicidation, commonly referred to as "salicidation", can be utilized to cover each floating gate with a refractory metal silicide layer consisting of titanium silicide or cobalt silicide. With the polysilicon of the floating gates exposed while the source/drain regions in the memory cells are covered with electrically insulating material, Choi's salicidation process involves depositing a layer of titanium or cobalt, heating the structure to form metal silicide layers by reaction of the titanium or cobalt with the polysilicon of the floating gates, and removing unreacted titanium or cobalt.

Independent Claims 23 and 24 are repeated below:

23. A method comprising:

forming a cobalt layer over a body which comprises a silicon-containing erasable programmable read-only memory region;

forming a titanium layer over the cobalt layer by ionized physical vapor deposition;

reacting cobalt of the cobalt layer with silicon of a doped silicon section of the erasable programmable read-only memory region to form a cobalt silicide layer; and

substantially removing the titanium layer and any unreacted cobalt of the cobalt layer.

24. A method comprising:

forming a cobalt layer over a body which comprises an erasable programmable read-only memory region that includes (i) a first section comprising doped monocrystalline silicon and (ii) a second section situated on the first section, an opening extending through the second section down to the first section;

forming a titanium layer over the cobalt layer by ionized physical vapor deposition;

reacting cobalt of the cobalt layer with silicon of the first section to form a cobalt silicide layer that contacts remaining material of the first section at the bottom of the opening; and

substantially removing the titanium layer and any unreacted cobalt of the cobalt layer.

Importantly, Claims 23 and 24 each recite that the titanium layer is formed over the cobalt layer by ionized physical vapor deposition.

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The Examiner alleges, on page 3 of the Office Action, that AAPA teaches "forming a titanium layer 130 over the cobalt layer 120 by ionized physical vapor deposition (i.e. sputtering)". This is incorrect.

AAPA discloses that titanium layer 130 is "sputter deposited" on cobalt layer 120. Sputter deposition is indeed a type of physical vapor deposition. However, the sputter deposition described in AAPA is not ionized physical vapor deposition.

Sputter deposition of metal on a body entails directing particles (typically ions) of a suitable bombardment species toward a target containing metal to be sputter deposited on the body. The bombarding particles cause particles of the target metal to be dislodged and move away from the target. Some of the dislodged particles of the target metal accumulate on the body to form a layer of the target metal on the body. Unless otherwise indicated, the particles of a target metal deposited by sputter deposition are largely electrically neutral as they travel from the target to the body on which the target metal is deposited.

A substantial portion of the target-metal particles can be ionized to enhance the sputter deposition characteristics. In that case, the deposition process is commonly referred to as ionized physical vapor deposition or, since the ionized particles of the target metal form a plasma, ionized metal plasma deposition. United States Patents 6,268,284 B1, 6,342,133 B2, and 6,503,824 B1, all of record, further describe ionized physical vapor deposition.

Nowhere does AAPA disclose, or in any way indicate, that a substantial portion of the sputter deposited titanium particles are ionized as they travel from the titanium target to cobalt layer 120 on which titanium layer 130 is formed. Absent such a disclosure, the sputter deposition described in AAPA is the type of titanium physical vapor deposition in which no substantial portion of the titanium particles are ionized as they travel from the titanium target to cobalt layer 120. That is, AAPA does not utilize ionized physical vapor deposition to form titanium layer 130 on cobalt layer 120. AAPA therefore does not teach the limitation of Claim 23 or 24 that a titanium layer be formed by ionized physical vapor deposition on a cobalt layer.

Choi does not disclose that ionized physical vapor deposition is employed to deposit titanium or any other material during fabrication of Choi's EPROM. Consequently, Choi does not teach the ionized-deposition limitation of Claim 23 or 24. Since AAPA does not teach the ionized-deposition limitation of Claim 23 or 24, the combination of AAPA and

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Choi would not teach the full subject matter of Claim 23 or 24 even if there were some motivation or suggestion for combining AAPA and Choi in the manner proposed by the Examiner. For this reason, Claims 23 and 24 are both patentable over AAPA taken with Choi.

Claim 25 depends from Claim 24. Claims 26, 50, 51, and 53 all depend (directly or indirectly) from Claim 23. Hence, dependent Claims 25, 26, 50, 51, and 53 are patentable over AAPA taken with Choi for the same reasons as Claims 23 and 24.

Claims 52, 54, and 55 have been rejected under 35 USC 103(a) as obvious based on AAPA taken with Choi and Lee, U.S. Patent Publication 2002/0001946 A1. This rejection is respectfully traversed.

Lee, although listed in the Form PTO-892 accompanying the present Office Action, was cited in the earlier Office Action mailed 30 September 2003. Substantially repeating what was stated in the 21 June 2004 Amendment, Lee discloses a semiconductor fabrication technique in which titanium film 22 is deposited on semiconductor substrate 21 by ionized physical vapor deposition, titanium nitride film 23 is formed on titanium film 22, and aluminum film 24 is formed on titanium nitride film 23. Aluminum film 24 functions as the primary interconnect metal for the metalization interconnect system.

Claims 52, 54, and 55 all depend from Claim 23. Hence, Claims 52, 54, and 55 all require that a titanium layer be formed by ionized physical vapor deposition on a cobalt layer.

Lee does form a titanium layer by ionized physical vapor deposition. However, Lee does not form a titanium layer on a cobalt layer. Nor does Lee even mention cobalt as far as Applicant's attorney can determine. Instead, Lee forms a titanium layer on a semiconductor substrate in order to increase the electromigration resistance of an aluminum layer later formed on a titanium nitride layer formed on the titanium layer.

Nothing in Lee would provide a person skilled in the art with any suggestion or incentive for using ionized physical vapor deposition to create a titanium layer on a cobalt layer, let alone to create a titanium layer on a cobalt layer in the course of forming a cobalt silicide layer. Consequently, there would be no reason for applying the teachings of Lee to AAPA or/and Choi. The combination of AAPA, Choi, and Lee does not teach the requirement of each of Claims 52, 54, and 55 that a titanium layer be formed by ionized

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physical vapor deposition on a cobalt layer. Claims 52, 54, and 55 are therefore patentable over AAPA taken with Choi and Lee.

Claims 56 and 57 have been objected to as dependent upon a rejected base claim but as being allowable if rewritten in independent form. Claims 56 and 57 both depend from Claim 23. Inasmuch as Claim 23 has been shown to be allowable over the applied art, Claims 56 and 57 are allowable in their current form.

Claims 58 - 60 have been indicated as being allowable if rewritten or amended to overcome the objections made to them. As indicated above, the objections to Claims 58 - 60 should now be removed. Also, Claims 58 - 60 all depend (directly or indirectly) from Claim 24. Since Claim 24 has been shown to be patentable over the applied art, Claims 58 - 60 are allowable in their present form.

The allowance of Claims 27, 28, 30, 32, 33, and 36 - 44 is noted.

Claims 29, 31, 34, 35, 45, and 46 have been indicated as being allowable if rewritten or amended to overcome the objections made to those claims. As indicated above, the objections to Claims 29, 31, 34, 35, 45, and 46 should now be withdrawn. Inasmuch as Claims 29, 31, 34, 35, 45, and 46 all depend (directly or indirectly) from allowed Claim 27, Claims 29, 31, 34, 35, 45, and 46 should now be allowed.

Claims 47 - 49 have been objected to as being dependent upon a rejected base claim but as being allowable if rewritten in independent form.

Claims 47 - 49 all depend from Claim 45 which, in turn, depends from Claim 27. Since Claim 27 has been allowed and since the objection to dependent Claim 45 should now be withdrawn, Claims 47 - 49 are allowable in their present form.

In short, the objections to Claims 29, 31, 34, 35, 45, 46, and 58 - 60 should be withdrawn. Claims 23 - 26 and 50 - 55 have been shown to be patentable over the applied art. Claims 47 - 49, 56, and 57 are allowable in their current form. Consequently, Claims 23 - 26, 29, 31, 34, 35, and 45 - 60 should be allowed along with already allowed Claims 27, 28, 30, 32, 33, and 36 - 44 so that the application may advance to issue.

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Respectfully submitted,



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